CLAIMS

1. A system for inspecting an item, comprising:
   a) a radiation source emitting a plurality of photons;
   b) a plurality of radiation detectors positioned to receive radiation from the radiation source after the radiation interacts with the item and to produce a pulse in response to a photon, each of the radiation detectors having a scintillating member and a light detector with a solid state element positioned to receive light from the scintillating member;
   c) a conveyance system for providing relative motion between the item and the path of radiation from the radiation source;
   d) a plurality of channels, each channel having:
      i) an input connected to an output of a respective radiation detector, and
      ii) an output representative of a number of pulses produced by the respective radiation detector during an interval of time; and
   e) a data processor receiving as inputs the outputs of the plurality of channels, the data processor processing the inputs to determine characteristics of objects within the item.

2. The system for inspecting an item of claim 1 wherein each of the output of each of the channels comprises a plurality of values, each value representing the number of pulses produced by the respective radiation detector with an amplitude in a predetermined range.

3. The system for inspecting an item of claim 1 wherein the solid state element comprises a photodiode.

4. The system for inspecting an item of claim 1 wherein each radiation detector produces a pulse with a rise and decay time of less than 40 nanoseconds in response to a photon.

5. The system for inspecting an item of claim 1 wherein the radiation source is an x-ray source.

6. The system for inspecting an item of claim 1 wherein the radiation source is gamma-ray source.

7. The system for inspecting an item of claim 1 wherein the radiation source is collimated to produce a fan beam.

8. The system for inspecting an item of claim 1 wherein the radiation source moves at least partially around the item and the data processor performs a computed tomographic reconstruction of the item.

9. The system for inspecting an item of claim 1 wherein the conveyance system comprises a conveyor belt moving relative to the source.

10. The system for inspecting an item of claim 1 wherein the conveyance system comprises a system for moving the radiation source relative to the item.

11. The system for inspecting an item of claim 2 wherein the conveyance system comprises a mobile vehicle or gantry for moving the radiation source relative to the item.

12. The system for inspecting an item of claim 11 wherein the system is adapted for inspecting cargo containers.

13. The system for inspecting an item of claim 1 wherein the scintillating member comprises Lutetium Oxysulfide.

14. The system for inspecting an item of claim 1 wherein the scintillating member comprises at least one of Cesium iodide and bismuth germanate.

15. The system for inspecting an item of claim 1 wherein the scintillating member comprises a crystal with a chemical composition including at least one rare earth element.

16 The system for inspecting an item of claim 1 wherein the plurality of radiation detectors comprises a one dimensional array.

17. The system for inspecting an item of claim 1 wherein the plurality of radiation detectors comprises a two dimensional array.

18. The system for inspecting an item of claim 17 wherein the two dimensional array comprises a plurality of linear arrays disposed along the direction of travel of the conveyor.

19. The system for inspecting an item of claim 18 wherein the data processor produces a representation of one portion of an item by combining outputs of channels coupled to radiation detectors in different ones of the plurality of linear arrays taken at different times.

20. The system for inspecting an item of claim 1 wherein each radiation detector is sized to receive radiation from the radiation source passing through an area of the item having a dimension of no more than 2mm.

21. The system for inspecting an item of claim 17 wherein each detector has an area less than 0.2 square mm.

22. The system for inspecting an item of claim 1 wherein each of the channels comprises at least one level sensitive circuit having an input coupled to the

output of a radiation detector, each level sensitive circuit producing an output in response to an input exceeding a predetermined level.

23. The system for inspecting an item of claim 22 wherein the outputs of each of the at least one level sensitive circuits is used in the image processor as an indication of the energy level of a photon interacting with the radiation detector.

24. The system of inspecting an item of claim 23 additionally comprising counting circuitry coupled to the outputs of each of the at least one level sensitive circuits, the counting circuits producing counts of the number of photons above at least one threshold energy interacting with each of the radiation detectors.

25. The system for inspecting an item of claim 23 wherein each channel additionally comprises a calibration circuit coupled to each of the at least one level sensitive circuits to change the predetermined level for each of the level sensitive circuits.

26. The system for inspecting an item of claim 23 wherein the radiation source provides photons at a spectrum of energy levels.

27. The system for inspecting an item of claim 23 wherein each of the channels comprises at least two level sensitive circuits and the output of the channel comprises at least two values, each value indicative of the number of pulses exceeding the predetermined level of each of the at least two level sensitive circuits in an interval of time.

28. The system for inspecting an item of claim 27 wherein the data processor computes a representation of the effective atomic number of a portion of an item from the relative values of the at least two values output from a group of channels, the group containing at least one channel.

29. The system for inspecting an item of claim 22 additionally comprising calibration circuitry coupled to the level sensitive circuit in a plurality of channels, the calibration circuitry adjusting the predetermined levels of the level sensitive circuits in each of said plurality of channels to give a more nearly equal response of level sensitive circuits coupled to adjacent radiation detectors to photons of similar energy levels.

30. The system for inspecting an item of claim 29 wherein the calibration circuitry adjusts the predetermined level by providing an offset to a predetermined value, wherein an offset is applied for each channel.

31. The system for inspecting an item of claim 29 wherein the calibration circuitry adjusts the predetermined level by providing a gain to a predetermined value, wherein a gain is applied for each channel.

32. The system for inspecting an item of claim 23 wherein the data processor comprises calibration software controlling the level sensitive circuits in a plurality of channels, the calibration software adjusting the predetermined levels of the level sensitive circuits in each of said plurality of channels.

33. The system for inspecting an item of claim 1 additionally comprising a plurality of pulse amplitude measuring circuits, each pulse amplitude measuring circuit having an input coupled to the output of a radiation detector and an output indicating the amplitude of a pulse produced by the radiation detector.

34. The system for inspecting an item of claim 33 wherein the plurality of pulse amplitude measuring circuits comprises at least one analog to digital converter.

35. The system for inspecting an item of claim 34 wherein the plurality of pulse amplitude measuring circuits comprises at least one integration circuit configured to integrate energy in a pulse produced by at least one radiation detector and the analog to digital converter is coupled to the radiation detector through the integration circuit.

36. The system for inspecting an item of claim 34 wherein the plurality of pulse amplitude measuring circuits comprises at least one sampling circuit and the analog to digital converter is coupled to the radiation detector through the sampling circuit.

37. The system for inspecting an item of claim 36 wherein the sampling circuit has a sampling interval that is short in comparison to the duration of a pulse produced by the detector.

38. The system for inspecting an item of claim 33 wherein the data processor is coupled to the pulse amplitude measuring circuits and the data processor counts pulses falling within predetermined ranges of amplitudes and different predetermined ranges are selected for different ones of the plurality of detectors using data gathered during a calibration routine.

39. The system for inspecting an item of claim 38 wherein the calibration software adjusts the predetermined ranges by applying a gain to a predetermined value, wherein a different gain may be applied for each channel.

40. The system for inspecting an item of claim 1 wherein the outputs of the plurality of light detectors are used to indicate attenuation of radiation by the item.

41. The system for inspecting an item of claim 40 wherein attenuation values are derived from the number of pulses with predetermined characteristics in a period of time.

42. The system for inspecting an item of claim 41 wherein the attenuation values are used to display an image of the item.

43. The system for inspecting an item of claim 41 wherein a plurality of attenuation values are derived from the number of pulses generated by groups of detectors in a time interval.

44. The system for inspecting an item of claim 43 wherein a plurality of attenuation values are generated for each group of detectors in a time interval, with each of said attenuation values being derived from the number of pulses having amplitudes meeting predetermined criteria during the time interval.

45. The system for inspecting an item of claim 44 wherein the plurality of attenuation values are used to create an image of an object depicting effective atomic number of objects within the item.

46. The system for inspecting an item of claim 1 wherein each of the channels comprises an integration circuit producing an integration of the output of each light detector over a predetermined interval.

47. The system for inspecting an item of claim 46 wherein the predetermined interval is about 0.8msec.

48. The system for inspecting an item of claim 1 wherein each of the channels comprises circuitry for aggregating coincident outputs of adjacent detectors.

49. The system for inspecting an item of claim 1 wherein the data processor makes a decision based on the characteristics of an object within the item.

50. The system for inspecting an item of claim 1 wherein the decision comprises outputting an indication of threat material within the item.

51. The system for inspecting an item of claim 1 additionally comprising a means for estimating the distance between the radiation source and the item.

52. The system for inspecting an item of claim 51 wherein the outputs of a plurality of detectors are aggregated prior to processing by the data processor selectively in response to the output of the height detector.

53. The system for inspecting an item of claim 52 wherein the number of detectors for which the outputs are aggregated is greater when the item has a height exceeding a threshold than when the item is below the threshold.

54. The system for inspecting an item of claim 53 additionally comprising a display displaying an image of the item derived from the outputs of each of the channels and the display has a greater resolution when the item has a height below the threshold.

55. The system for inspecting an item of claim 1 wherein the output of each of the channels is a digital value.

56. The system for inspecting an item of claim 1 wherein each of the channels comprises an amplifier connected to the output of its respective radiation detector.

57. The system for inspecting an item of claim 1 wherein the conveyor is between the radiation source and the plurality of radiation detectors, whereby the radiation detectors detect radiation attenuated upon passing through the item.

58. The system for inspecting an item of claim 1 wherein the radiation source and the plurality of radiation detectors are on the same side of the conveyor, whereby the radiation detectors detect radiation scattered from the item.

59. The method of claim 1 wherein processing the inputs comprises performing a tomographic reconstruction of at least a portion of the item based.

60. The method of claim 59 wherein the tomographic reconstruction is based on the density of the item.

61. A system for inspecting an item, comprising:

a) a radiation source emitting a plurality of photons;

b) a plurality of means for producing identifiable pulses, each pulse being produced in response to an individual interaction between a photon from the radiation source and a scintillation detector after the radiation has interacted with a portion of the item;

c) means to position the item in the path of radiation from the radiation source;

d) a plurality of channels, each channel comprising means for making a plurality of counts of pulses produced by one of the plurality of means for producing, each of the counts representing a number of pulses with an amplitude in a predetermined range; and

e) means for analyzing the counts of pulses to form a representation of the item.

62. The system for inspecting an item of claim 61 wherein each scintillation detector has an active area facing the radiation source of less than 1 square mm.

63. The system for inspecting an item of claim 61 wherein each scintillation detector has an active area facing the radiation source of less than 0.2 square mm.

64. The system for inspecting an item of claim 61, additionally comprising: means for using the representation of the item for identifying contraband inside the item.

65. The system for inspecting an item of claim 61, wherein the means for making a plurality of counts comprises a plurality of sampling circuits, whereby the output of each of the plurality of means for producing identifiable pulses is converted into a stream of digital values.

66. The system for inspecting an item of claim 61, wherein each scintillation detector comprises a solid state detector.

67. The system for inspecting an item of claim 66 wherein the means for making a plurality of counts comprises means for counting pulses representative of photons in two energy bands.

68. The system for inspecting an item of claim 67 wherein the radiation source generates radiation at a spectrum of energy levels.

69. The system for inspecting an item of claim 67 wherein the radiation source generates radiation at energies below 150KeV.

70. The system for inspecting an item of claim 67 wherein the means for analyzing the counted pulses comprises means for comparing the relative numbers of pulses in each energy band.

71. The system for inspecting an item of claim 61, wherein the means for analyzing comprises means for combining counts of pulses produced by different ones of the plurality of means for producing identifiable pulses made at different times.

72. The system for inspecting an item of claim 71 additionally comprising a means to estimate the distance between the radiation source and the item, and wherein the means for combining is responsive to the output of the means for estimating distance.

73. The system for inspecting an item of claim 61, additionally comprising means for calibrating the plurality of means for producing identifiable pulses.

74. The system for inspecting an item of claim 73 additionally comprising a plurality of sampling circuits, whereby the output of each of the plurality of means for producing identifiable pulses is converted into a stream of digital values and the means for calibrating comprises means for altering the digital values based on measurements taken during a calibration phase.

75. The system for inspecting an item of claim 73 additionally comprising a plurality of thresholding circuits, whereby the output of each of the plurality of means for producing identifiable pulses is converted into a plurality of streams of pulses based on the magnitude of the pulses and the means for calibrating comprises means for altering the threshold level of each of the thresholding circuits based on measurements taken during a calibration phase.

76. The system for inspecting an item of claim 61 comprising means for reducing the rate at which pulses are generated by the means for producing identifiable pulses.

77. The system for inspecting an item of claim 76 wherein the means for reducing the rate at which pulses are generated comprises a plurality of arrays of small detectors.

78. The system for inspecting an item of claim 61 wherein the radiation source and detector move relative to the item and the means for analyzing the counted pulses performs a tomographic reconstruction of the item.

79. A method of operating a system for inspecting an item comprising a plurality of detectors that each produce a pulse in response to a photon incident on the detector, the method comprising:

a) calibrating the plurality of detectors to correlate the level of the pulse produced by each detector with an energy levels photons incident on the detector;

b) counting pulses with levels representative of a least three energy levels produced by the plurality of detectors;

c) combining the counts of the pulses into a representation of the item;

c) analyzing the representation of the item to determine properties of objects within the item based in part on the relative number of counts of each energy level.

80. The method of claim 79 wherein the pulses have a magnitude representative of the energy of the photon interacting with the detector and combining the counted pulses into a representation of the item includes an indication of the atomic number of material within the item derived from relative counts of pulses with different magnitudes.

81. The method of claim 80 wherein calibrating the plurality of detectors comprises:

radiating the plurality of detectors without an item present and collecting calibration data; and the method additional comprises scaling the magnitude of the pulses from each detector based on the calibration data prior to combining the counted pulses into a representation of the item.

82. The method of claim 79 additionally comprising moving the item relative to a detector array and combining counts of pulses generated by different detectors at different times representing photons passing through the same area of the item.

83. The method of claim 79 wherein the at least three energy levels comprises at least two energy bins above 20keV.

84. The method of claim 83 wherein the at least three energy levels comprises at least two energy bins above 40 keV.